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A fiber-optic chemical sensor has been developed using laser induced fluorescence (LIF) to provide high resolution, real-time, in-situ field detection of underground petroleum contamination. Recent experiments using a 308 nm XeCl laser source have shown improved performance, particularly at detecting light molecular weight (i.e. aviation) fuels.

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59 - 1996

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Abstract

A fiber-optic chemical sensor has been developed using laser induced fluorescence (LIF) to provide high resolution, real-time, in-situ field detection of underground petroleum contamination. Recent experiments using a 308 nm XeCl laser source have shown improved performance, particularly at detecting light molecular weight (i.e. aviation) fuels.

Laser induced fluorescence spectroscopy for *in-situ* detection of petroleum contamination

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Fuel storage tanks, hidden underground at sites such as gasoline stations and airports throughout the world, are leaving an unexpected legacy: the soil beneath the tank is often heavily contaminated with toxic hydrocarbons that may have been leaking for decades.[1] Studies have shown that certain components of fuels are carcinogenic, and while natural bacteria will slowly degrade most hydrocarbons, the carcinogenic compounds can remain in the ground long after the source has been removed.

The need for rapid assessment of such sites has led to the development of spectroscopic systems that are capable of remotely measuring the presence of underground petroleum contamination. [2-4] These systems use laser induced fluorescence (LIF) to detect the presence of petroleum products by exciting fluorescence in a component of most petroleums, the polynuclear aromatic hydrocarbons (PAHs). The PAHs are typically excited in the UV, in our case using a 337 nm nitrogen laser, and the emission is characteristically Stokes shifted towards the visible [5]. Because petroleum compounds are a complex mixture of different PAHs (along with a large range of alkanes, cycloalkanes and other organic compounds), the emission spectrum is a convolution of a large number of individual molecular spectra. While it is not possible to deconvolve the measured spectrum to determine the exact composition of the contaminant, the spectral shape of the emission does provide information on the class of fuel that may be present underground, and the intensity of the fluorescence is related to the concentration of the contamination.[6]

We have recently begun experiments using a 308 nm XeCl laser in place of the nitrogen laser as the pump source for our LIF petroleum sensor. Roughly speaking, the energy needed for exciting the PAHs is inversely related to the number of rings so the shorter wavelength of the XeCl laser is able to more efficiently excite fluorescence in lighter fuels that contain only one and two ring PAHs, such as jet fuels, which have been difficult to detect using the nitrogen laser. The XeCl source also appears to improve the detection limit compared to the nitrogen laser system, perhaps due to stronger absorption at the shorter wavelengths. The effects of different excitation wavelengths on the measured spectral shapes for various fuel types is still under investigation. We will present the results of field investigations at various contaminated sites, as well as laboratory studies to compare the predicted performance of the XeCl and nitrogen laser based systems.

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